Extended abstract submitted to the TOUGH Workshop '95
Lawrence Berkeley Laboratory, Berkeley, CA, March 20-22, 1995

SIMULATION OF THE HEBER GEOTHERMAL FIELD, A TOUGH2/PC APPLICATION

Emilio Antúnez[1], Marcelo Lippmann[1], M. Ali Khan[2], and Timothy Boardman[3]

[1] Lawrence Berkeley Laboratory, Berkeley, CA
[2] California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, Santa Rosa, CA
[3] California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, El Centro, CA

ABSTRACT

A numerical simulation model for the Heber geothermal field in southern California is being developed under a technology transfer agreement between the Department of Energy/LBL and the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (Division). The two objectives of the cooperation are: (1) to train Division personnel in the use of the TOUGH2/PC computer code; and (2) to develop a module compatible with TOUGH2 to investigate the effects of production/injection operations on the ground surface subsidence-rebound phenomenon observed in the field. The compaction of the rock formation will be handled assuming an elastic behavior of the rock-fluid system. Considered will be changes in pore volume and in-grid block dimensions, as well as, the process by which the change in formation volume is transmitted to the surface (vertical deformation; subsidence and rebound).

Introduction

The Division has among its diverse functions: (1) the supervision of oil, gas, and geothermal fields; (2) the gathering of production/injection data; and (3) forecasting the behavior of fields including the amount of ground surface subsidence and rebound caused by exploitation. So far, the Division's forecast of fluid production/injection has been based on modeling data provided by the field operators. When these data are not available, the Division has used first-order methods for its forecasts. At times, these methods may be inappropriate for the task. For this reason, the Division requested the assistance of the U.S. Department of Energy (DOE) in training of its personnel on the use of TOUGH2 (Pruess, 1991).

The Division and LBL collaboration began in early 1994 with funding from DOE's Geothermal Division. So far, the Division's personnel have received introductory training on the use of TOUGH2, have been instructed on the kind of field data relevant to reservoir behavior prediction, and asked to choose a geothermal field to built a numerical model using actual data. The Heber geothermal field in southern California was selected.

A numerical model of Heber is under development. The field has experienced up to six inches of subsidence at the center of the production area and shown up to seven inches of ground surface rebound due to injection (Fig. 1). Therefore, there are plans to write and include a new module to TOUGH2 to account for subsidence and rebound; this adds research significance to the collaborative work.

The training will continue with discussions on the calibration of a numerical model using the TOUGH2/PC simulation code (Antúnez *et al.,* 1994) and on the use of the model as a predictive tool. This training will undoubtedly benefit the Division's regulatory activities. Through this collaboration, LBL is helping to transfer the technology developed under DOE-funded programs.

Objectives

LBL will:

1. train two Division engineers in the use of LBL's general purpose simulator TOUGH2/PC;

2. develop a TOUGH2 compatible computer code module that will help to analyze the ground surface subsidence and rebound in the Heber geothermal field. The module will include elastic changes in pore volume and in grid-block dimensions in response

to the changes in the compressibility of the rock-fluid system. The process by which the lost (compacted) volume is transmitted to the surface (subsidence) will also be considered;

3. test and verify the new module using synthetic and field data;

4. train the Division engineers on how to construct a numerical model using the Heber field data as an example, how to calibrate it, and use it in field development and monitoring; and

5. conduct simulation runs with the modified version of TOUGH2/PC to develop guidelines to control or minimize changes in ground surface elevation.

So far, all the Heber data gathered by the Division has been reviewed and inventoried. After reviewing the data, a decision was made that a N-S grid orientation was adequate for the Heber model (see Fig. 1). Dimensions of the model were set at 14 km (N-S) by 13 km (E-W), and a thickness of 3 km (10,000 ft) with the thermal anomaly approximately at the center of the grid.

Considering the available data, discussions with the Division engineers, and a paper by E.D. James et al. (1987), it was decided to subdivide the model in eight horizontal layers. Eight maps showing isotherms at 150, 425, 700, 1050, 1450, 1829, 3000, 3048 m (490, 1390, 2300, 3440, 4760, 6000, 9840, and 10,000 ft respectively) below sea level were sketched. The first seven elevations correspond to the middle of each layer; the last one to the bottom of the model. The isotherms at 1829 m (6000 ft) below sea level are shown in Figure 2.

Currently, the gridding for each layer is in progress; this requires the exact location of the completion intervals from all wells. The intervals are available but are reported in terms of measured depth. A correction is required to obtain their true vertical depth and location in California coordinates. LBL wrote the program to make these corrections and the Division staff is presently processing the well directional surveys.

Simultaneous to the previous task, LBL and the Division are collecting information on the physical properties of rock types present in Heber's lithological column (clays, sandstones and indurated sediments).

ACKNOWLEDGMENTS

The authors want to express their gratitude to Karsten Pruess and Curt Oldenburg of LBL for reviewing this manuscript and for all their helpful suggestions. This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Geothermal Division, of the U.S. Department of Energy under contract No. DE-AC03-76SF00098.

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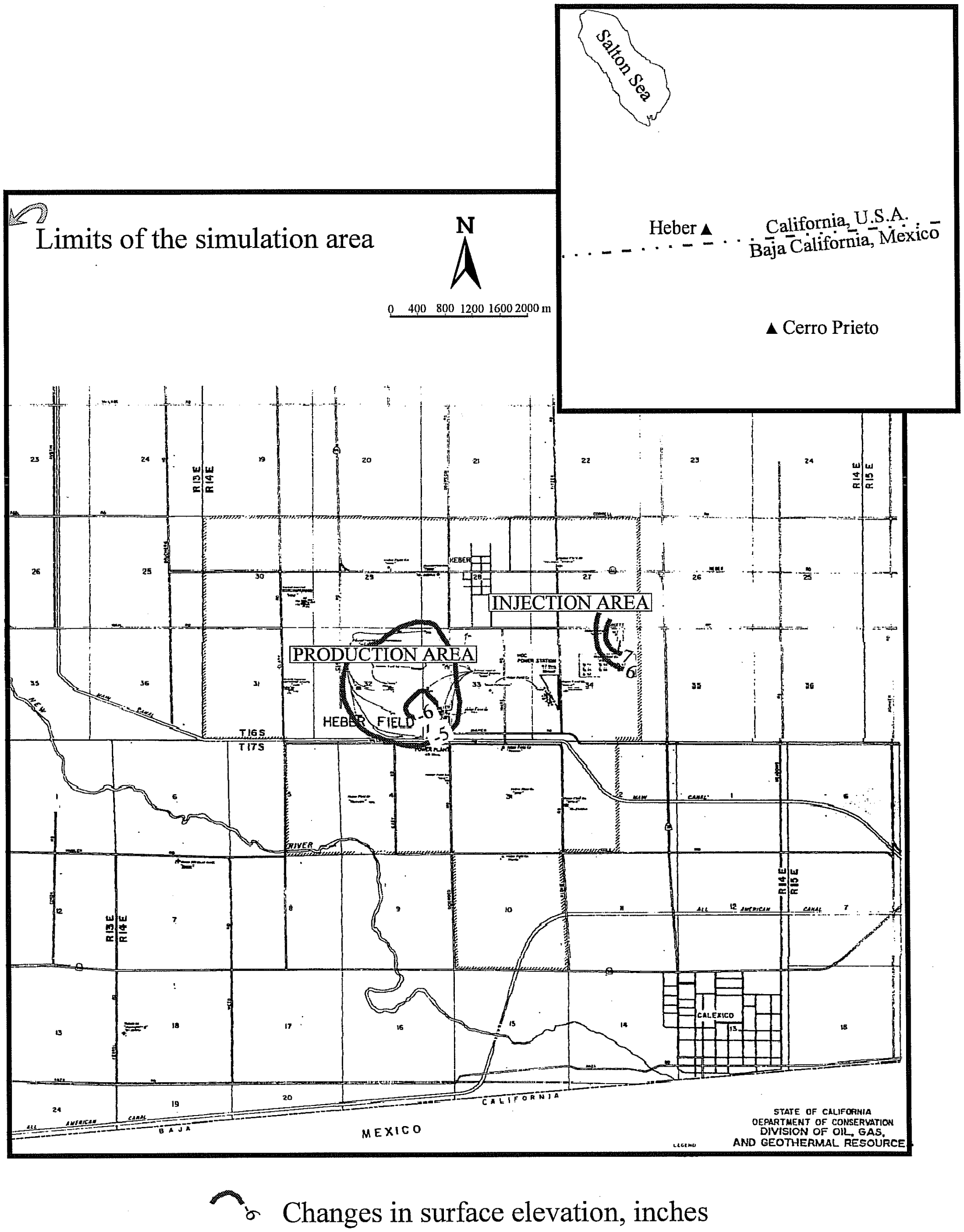

Fig. 1: Base map of the Heber geothermal field, showing subsidence in the production area, rebound in the injection zone, and limits of the simulation area.

Isotherms at 1,829 m (6,000 ft) below sea level

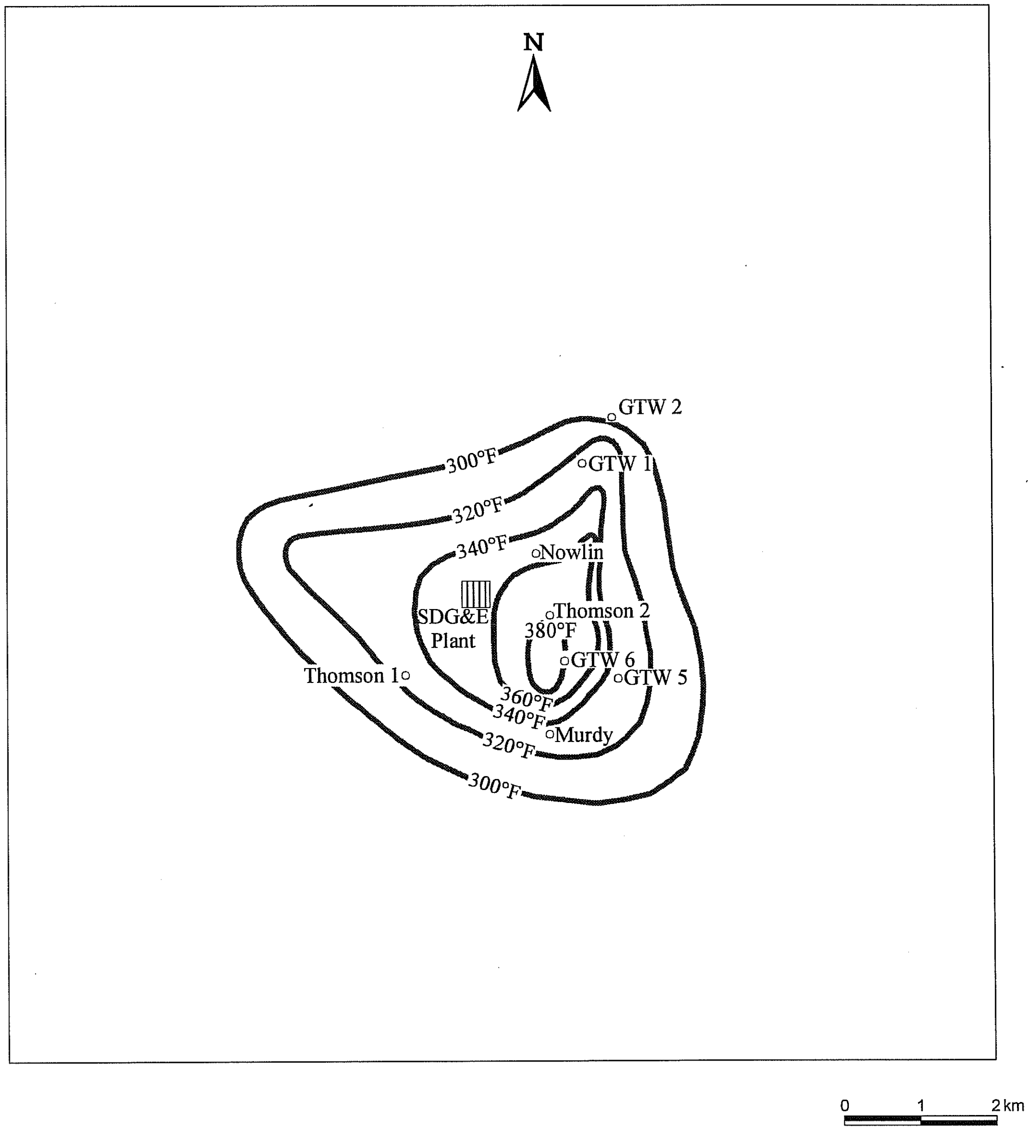

Fig. 2: Heber geothermal field, limits of the simulation area, and inferred isotherms at 1,829 m (6,000 ft) below sea level